Title/Subject: Design Criteria for Microprocessor Based Motor Overload Protection Systems		
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Design Criteria for Microprocessor Based Motor Overload Protection Systems

1.0 Purpose

This document specifies the Mine Safety and Health Administration's (MSHA's) design criteria for systems utilizing microprocessor technology to protect motors on approved equipment against a specific overcurrent condition known as overload.

2.0 Scope

These criteria apply to all underground mine operators and manufacturers of mining equipment approved under Title 30 Code of Federal Regulations (30 CFR), Part 18.

3.0 Reference

3.1 Electrical Division Document System APOL2153 “Policy on Motor Overload Protection”

3.2 30 CFR Part 18.51(b) and 18.20(b)

4.0 Definitions

4.1 Microprocessor - A microprocessor is a solid state electronic device, typically implemented in one or more integrated circuits (ICs). When the microprocessor is combined with (external) memory and input/output (I/O) devices, a microcomputer is formed. The execution of a computer program takes place in the microprocessor. It contains the Central Processing Unit (CPU) which consists of an Arithmetic Logic Unit (ALU), internal memory, appropriate registers, and control circuitry (Control Unit).

4.2 Overcurrent - An abnormal current greater than the full load value. The term "overcurrent" includes short-circuit and overload currents.

4.3 Overload - An electrical motor "overload" is an overcurrent which, should it persist long enough, would cause dangerous overheating. Motor overheating tends to occur during an unusually long start time, during multiple re-starts in a short time interval, and when the motor's normal duty cycle (current versus time) is exceeded.

4.4 Watchdog Timer- Circuitry or software which, during successive predetermined time intervals, monitors for critical values of electrical parameters and completion of programmed actions in a computerized control system, and when fault is sensed, either terminates operation or activates an alarm.

5.0 Background

5.1 30 CFR, Section 18.20(b) requires that the design and construction of electrical equipment be based on sound engineering principles and that the equipment be safe for its intended use. 30 CFR, Section 18.20(b) also authorizes MSHA to modify design, construction, and test requirements to accommodate unforeseen technology, so long as the same degree of protection is afforded as that provided by the tests described in Subpart C of 30 CFR, Part 18.

5.2 30 CFR, Section 18.51(b) mandates that each motor shall be protected by an automatic overcurrent device, which protects against excessive short circuit and overload currents. One type of overload protection system utilizes a microprocessor. The microprocessor based protection system is a computerized control system programmed to determine that a motor overload exists and calculate a commensurate cooling interval and de-energize the motor before thermal damage can occur, and then preclude motor re-start until the cooling interval has elapsed.

6.0 Criteria

6.1 Microprocessor based motor overload protection systems:

6.1.1 Must incorporate automatic testing, prior to motor start, to check the integrity of the system's RAM and ROM Memory Units, Input and Output signal processing circuitry, and the Central Processing Unit (CPU), including its Arithmetic Logic Unit (ALU), Control Unit, Internal Memory, and Registers. Motor start must be precluded if a test is failed.

6.1.2 Must incorporate a **Watchdog Timer**, built on "fail-safe" principles, or comparable circuitry to continually test for proper supply voltage to the microprocessor and for program execution by the computer.

NOTE: REFER TO THE SYSTEM BLOCK DIAGRAM, FIGURE 1, FOR INTERCONNECTION OF A TYPICAL SYSTEM

6.1.3 Must receive, as input from a sensor, an electrical signal of magnitude proportional to either the motor's current or the instantaneous temperature of the hottest spot of the motor's frame. If current is the sensed parameter then the overload protection must comply with EDDS No. APOL2153, “Policy on Motor Overload Protection”. If temperature is the sensed parameter, then the device must interrupt current in all ungrounded conductors when the sensed temperature is greater than the sum of the motor’s rated temperature rise and the rated ambient.

6.1.4 Must be designed such that failure to execute the program (Ref. 6.1.2) must either preclude motor start or de-energize the motor if already started;

6.1.5 Must incorporate means to generate an **Alarm Signal** to preclude motor damage from overload, in conformance with the motor's thermal characteristics and the response

time of the motor's contactor or equivalent device;

6.1.6 Must incorporate a **Primary Means** to automatically de-energize the motor in response to the Alarm Signal (Ref. 6.1.5);

6.1.7 Must incorporate means which precludes motor voltage for a **Cooling Interval** following motor de-energization, in conformance with the motor's thermal characteristics;

6.1.8 Must incorporate means which precludes automatic motor restart following the Cooling Interval (Ref. 6.1.7);

6.1.9 Must incorporate means which precludes manual override by Operator controls of any function of the microprocessor-based motor overload protection system;

6.1.10 Must be designed such that the microprocessor algorithm can not be altered except by a factory representative. Such alteration may be performed only after permission is granted from MSHA;

6.1.11 Must not be the sole means of protecting against motor overload on equipment in which the motor(s) and the microprocessor-based motor protection system are energized simultaneously and de-energized simultaneously.

QUALIFICATION

Criterion 6.1.11 is waived if the microprocessor-based motor protection system employs non-volatile memory and timing and associated means to effectively account for motor heating from closely spaced multiple starts and stops, notwithstanding concurrent interruptions of the microprocessor input

power. (Such interruptions can result, for example, when any outby-switched motor is "inched" or when an outby-switched cutter motor repeatedly stalls and trips the outby breaker when sumping into extraordinary face material).

6.2 To provide a more complete and effective motor protective device, the microprocessor-based motor overload protection system:

6.2.1 *Should* incorporate automatic testing for zero motor current after the Alarm Signal (Ref. 6.1.5) commands the Primary Means (Ref. 6.1.6) to de-energize the motor; test failure *should* cause the microprocessor system to generate a **Failure Signal**;

6.2.2 *Should* incorporate a **Secondary Means**, which the Failure Signal (Ref. 6.2.1) activates. The Secondary Means *should* automatically de-energize the motor when the Primary Means (Ref. 6.1.6) does not de-energize the motor when commanded.

QUALIFICATIONS

Equipment for which motor(s) and the motor protection system(s) can only be energized simultaneously and de-energized simultaneously (typically by an outby contactor or circuit breaker) are exempted.

Exempted equipment *should* also include the **Secondary Means** which the Failure Signal (Ref. 6.2.1) activates, plus an **Audible or Visual Alarm Device**. The Secondary Means *should* automatically activate the Audible or Visual Alarm Device to alert personnel when the Primary Means (Ref. 6.1.6) fails to de-energize the overloaded motor as commanded.

6.2.3 *Should* preclude voltage to the motor when multiple, closely spaced restarts heat the motor to such degree that subsequent run at normal duty cycle would result in thermal damage.

7.0 Distribution

Electrical Safety Division (ESD) personnel and other interested parties.

8.0 Results

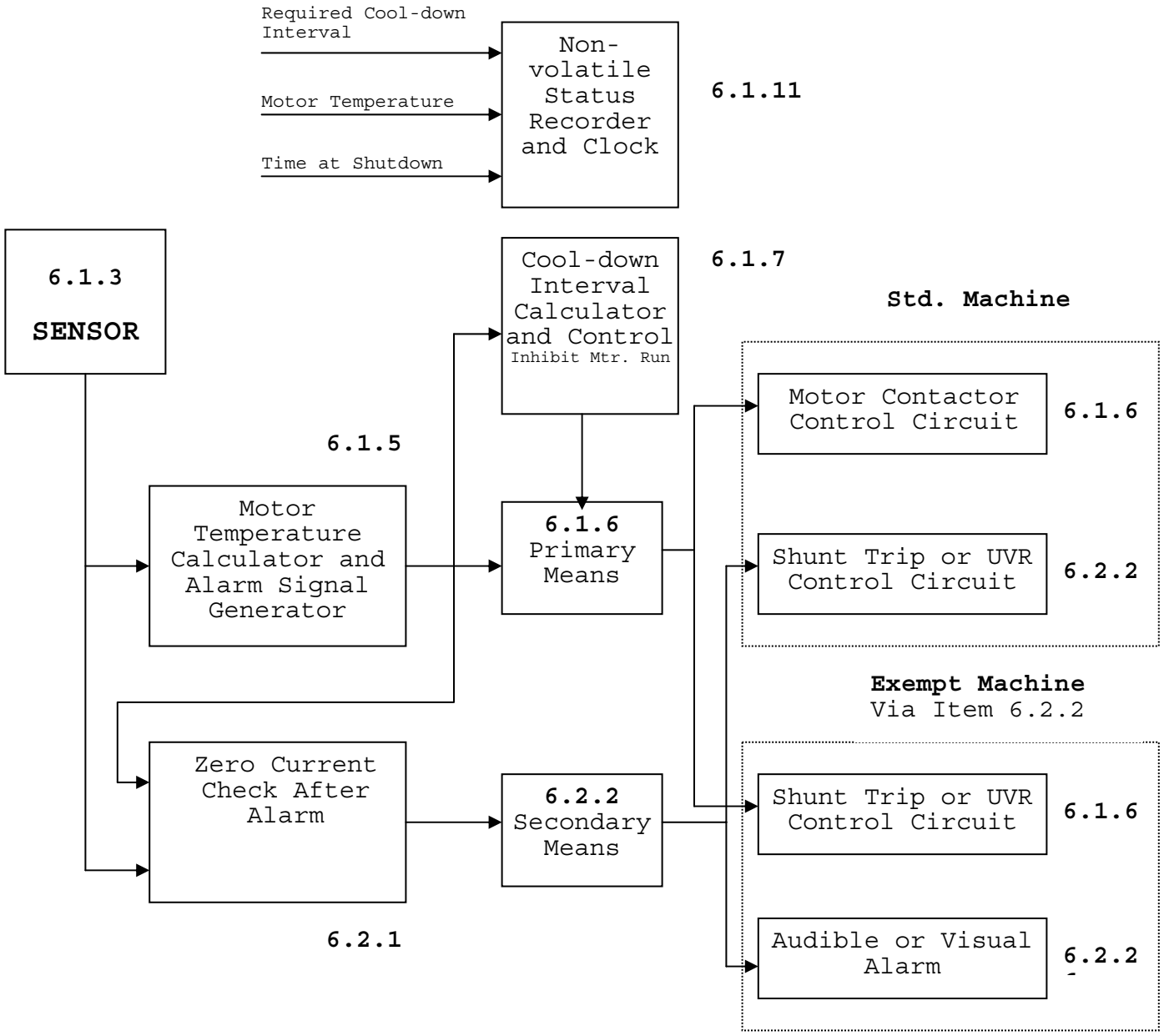
To provide Electrical Safety Division personnel and other interested parties with the criteria used to evaluate microprocessor based overload protection systems.

9.0 Review

This document will be reviewed at least once every three years.

10.0 Authority

Title 30 Code of Federal Regulations, Sections 18.20(b) and 18.51(b).



Microprocessor Based Motor Overload Protection System

Figure 1